US009043362B2

(12) **United States Patent**
Weissman et al.

(10) **Patent No.: US 9,043,362 B2**

(45) **Date of Patent: *May 26, 2015**

(54) **CUSTOM ENTITIES AND FIELDS IN A MULTI-TENANT DATABASE SYSTEM**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 7 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/281,607**

(22) Filed: **Oct. 26, 2011**

(65) **Prior Publication Data**

US 2012/0041986 A1 Feb. 16, 2012

Related U.S. Application Data

(63) Continuation of application No. 12/764,780, filed on Apr. 21, 2010, now Pat. No. 8,112,445, which is a continuation of application No. 10/817,161, filed on Apr. 2, 2004, now Pat. No. 7,779,039.

(51) **Int. Cl.**
G06F 7/00 (2006.01)
G06F 17/30 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 17/30595*** (2013.01); ***G06F 17/30607*** (2013.01)

(58) **Field of Classification Search**
USPC 707/999.101, 790, 791
See application file for complete search history.

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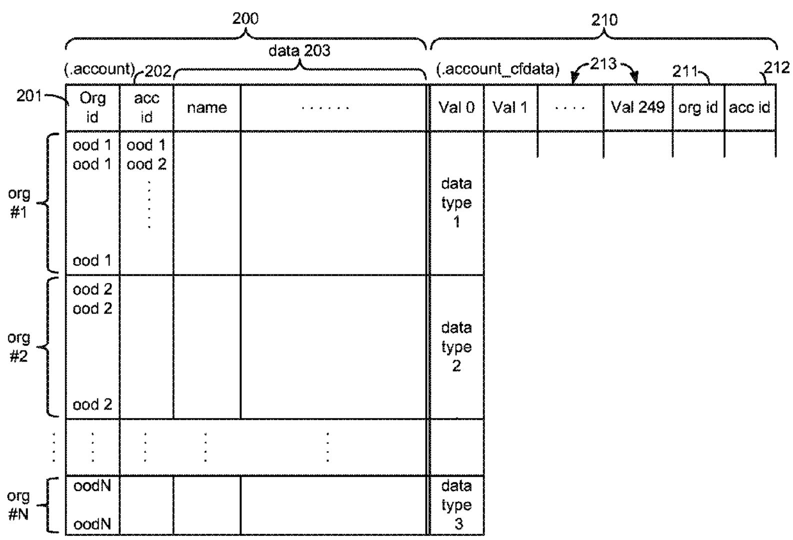
(57) **ABSTRACT**

Systems and methods for hosting variable schema data such as dynamic tables and columns in a fixed physical database schema. Standard objects, such as tables are provided for use by multiple tenants or organizations in a multi-tenant database system. Each organization may add or define custom fields for inclusion in a standard object. Custom fields for multiple tenants are stored in a custom data column within the object data structure, and this single custom data column may contain different data types for each tenant.

20 Claims, 8 Drawing Sheets



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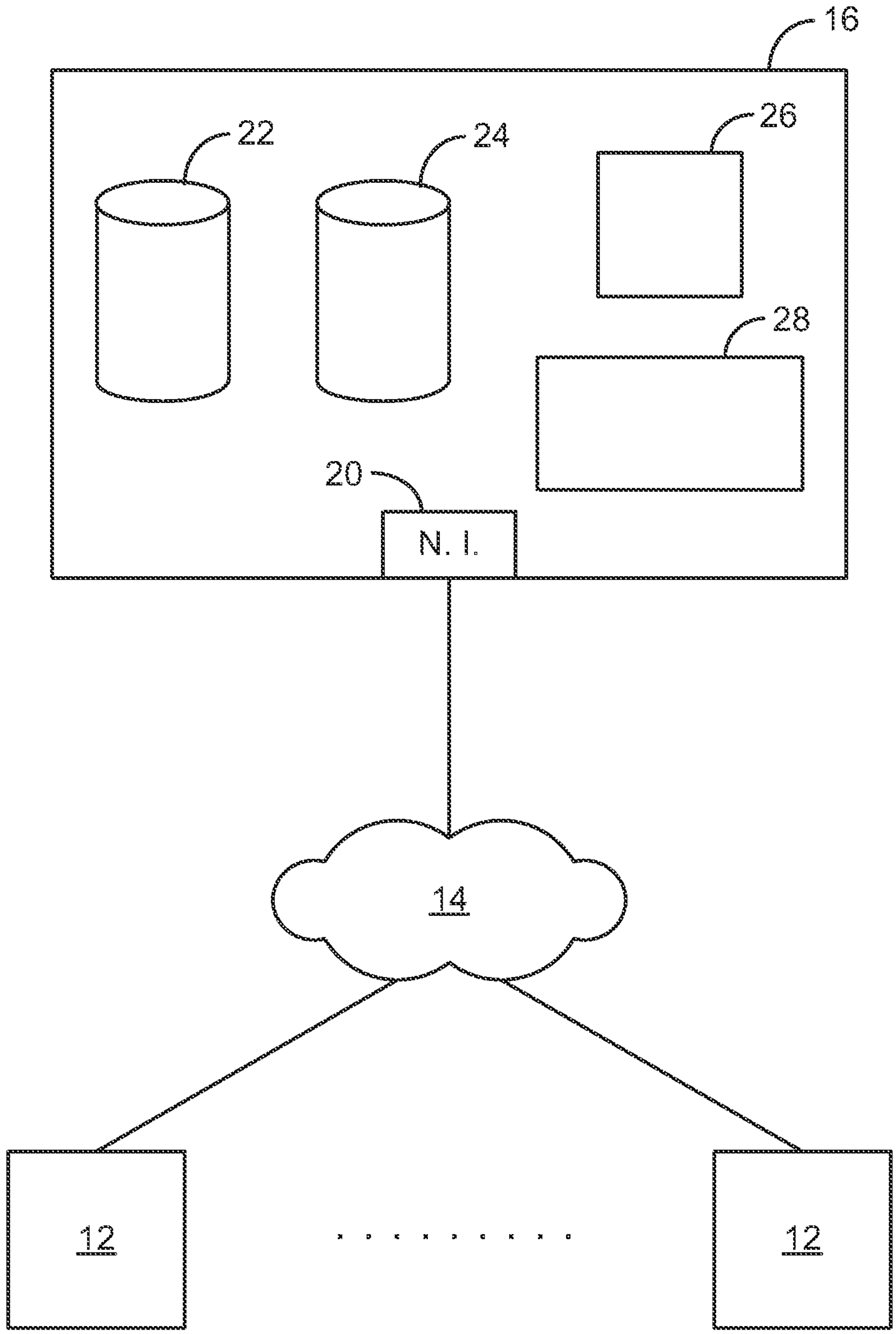


FIG. 1

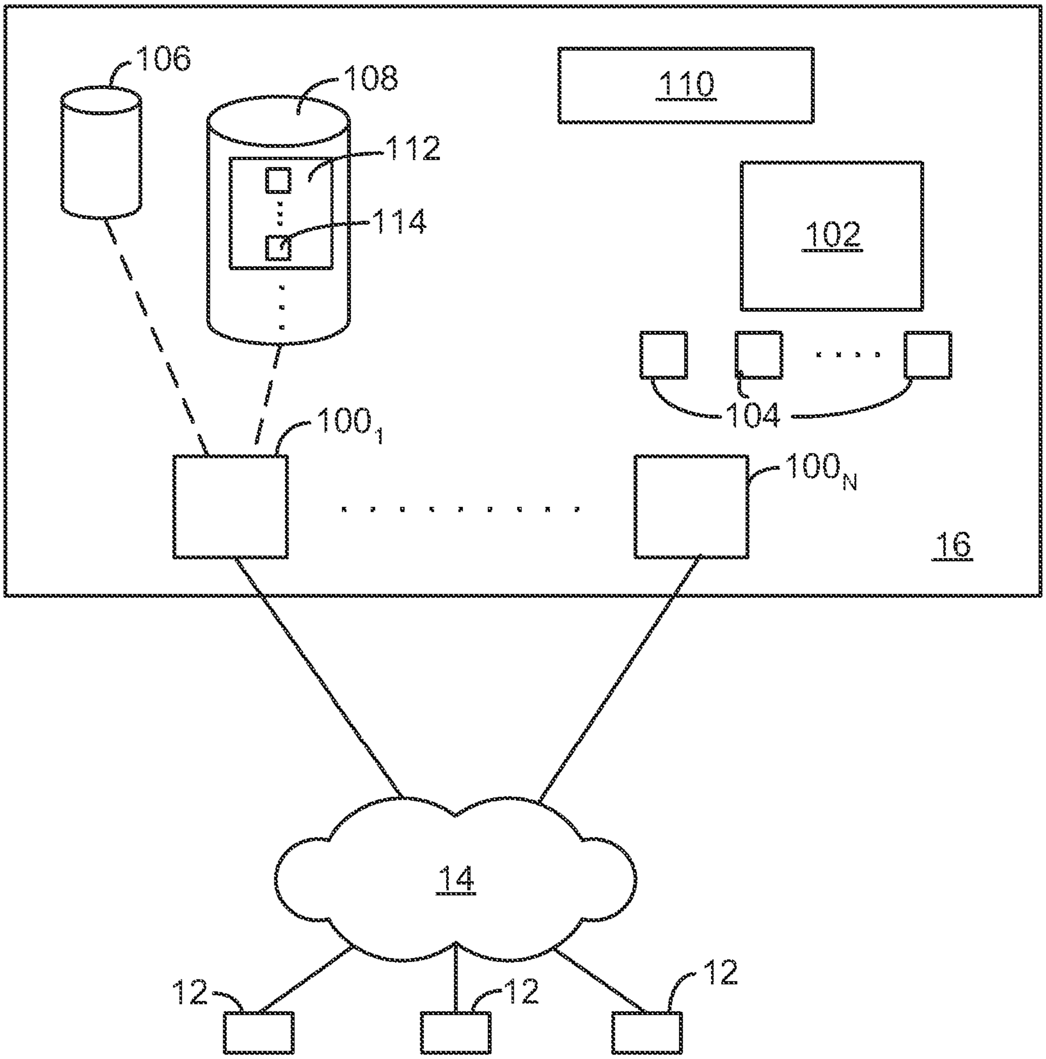


FIG. 2

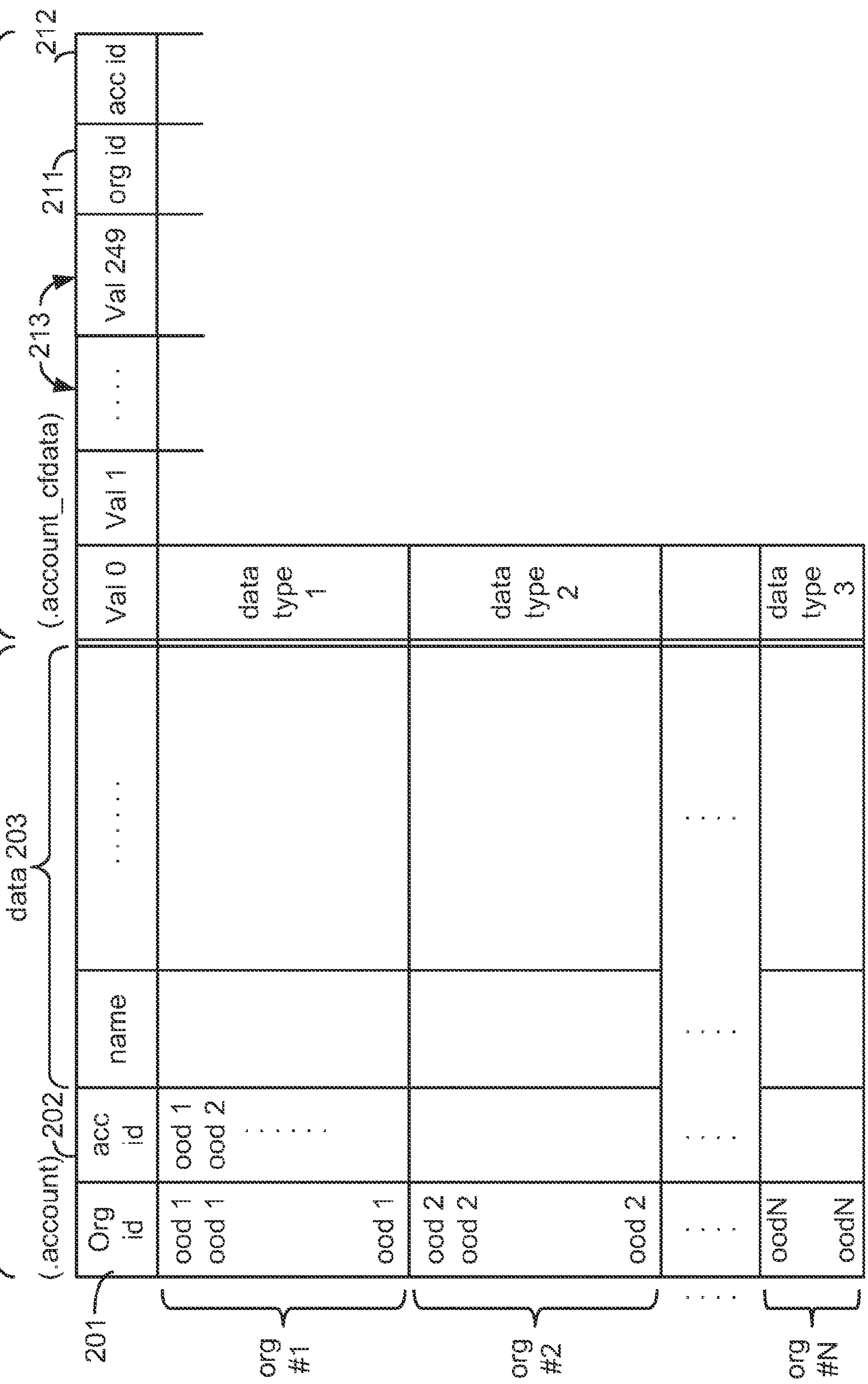
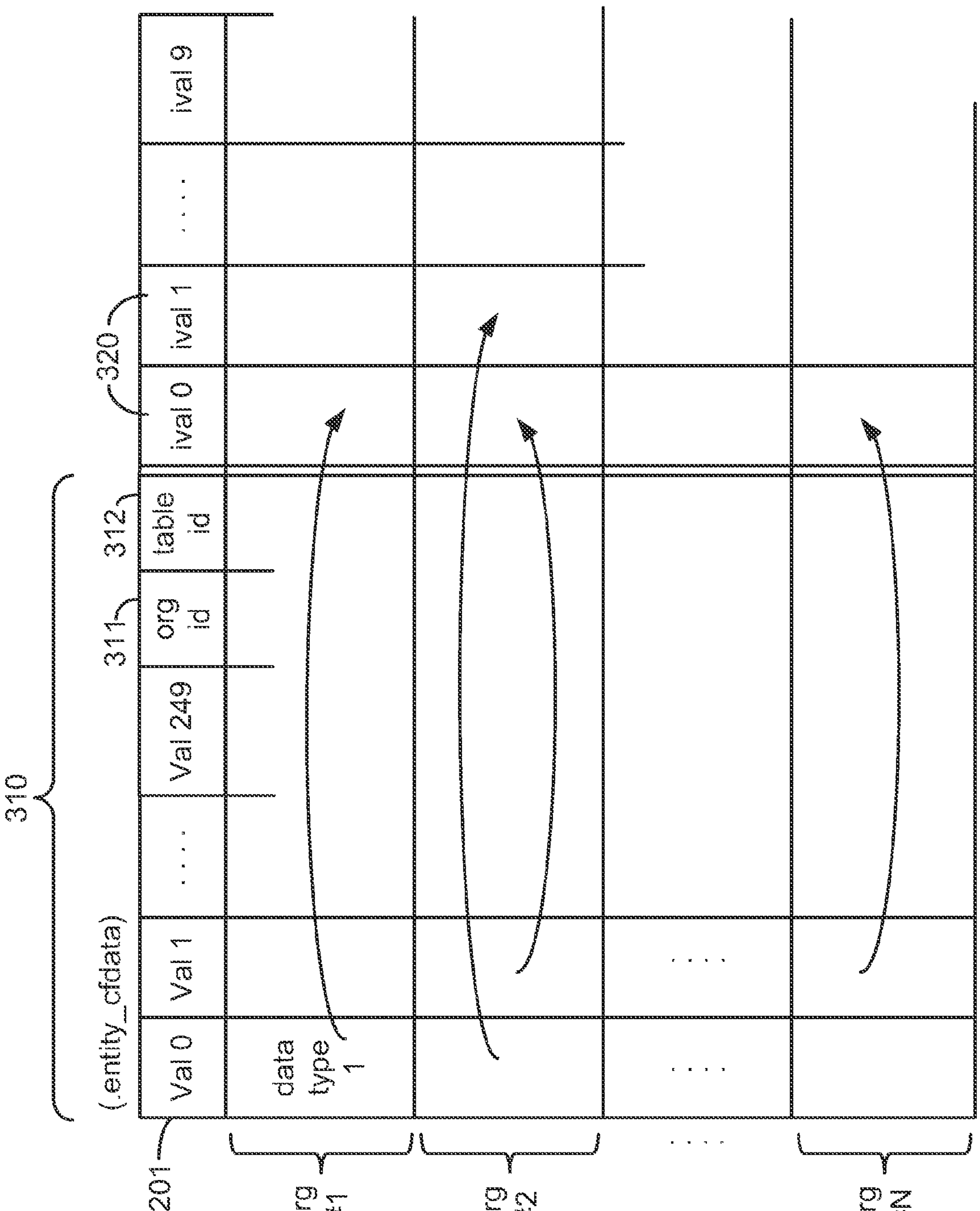

200
210
(.account)
data 203
(.account_cfdata)
202
211
212
213
Org id
acc id
name
Val 0
Val 1
Val 249
org id
acc id
ood 1
ood 2
data type 1
data type 2
data type 3
oodN
201
org #1
org #2
org #N

FIG. 3



310
(.entity_cfdata)
Val 0
Val 1
. . . .
Val 249
org id
table id
311
312
ival 0
ival 1
. . . .
ival 9
320
data type 1
. . . .
201
org #1
org #2
org #N

FIG. 4

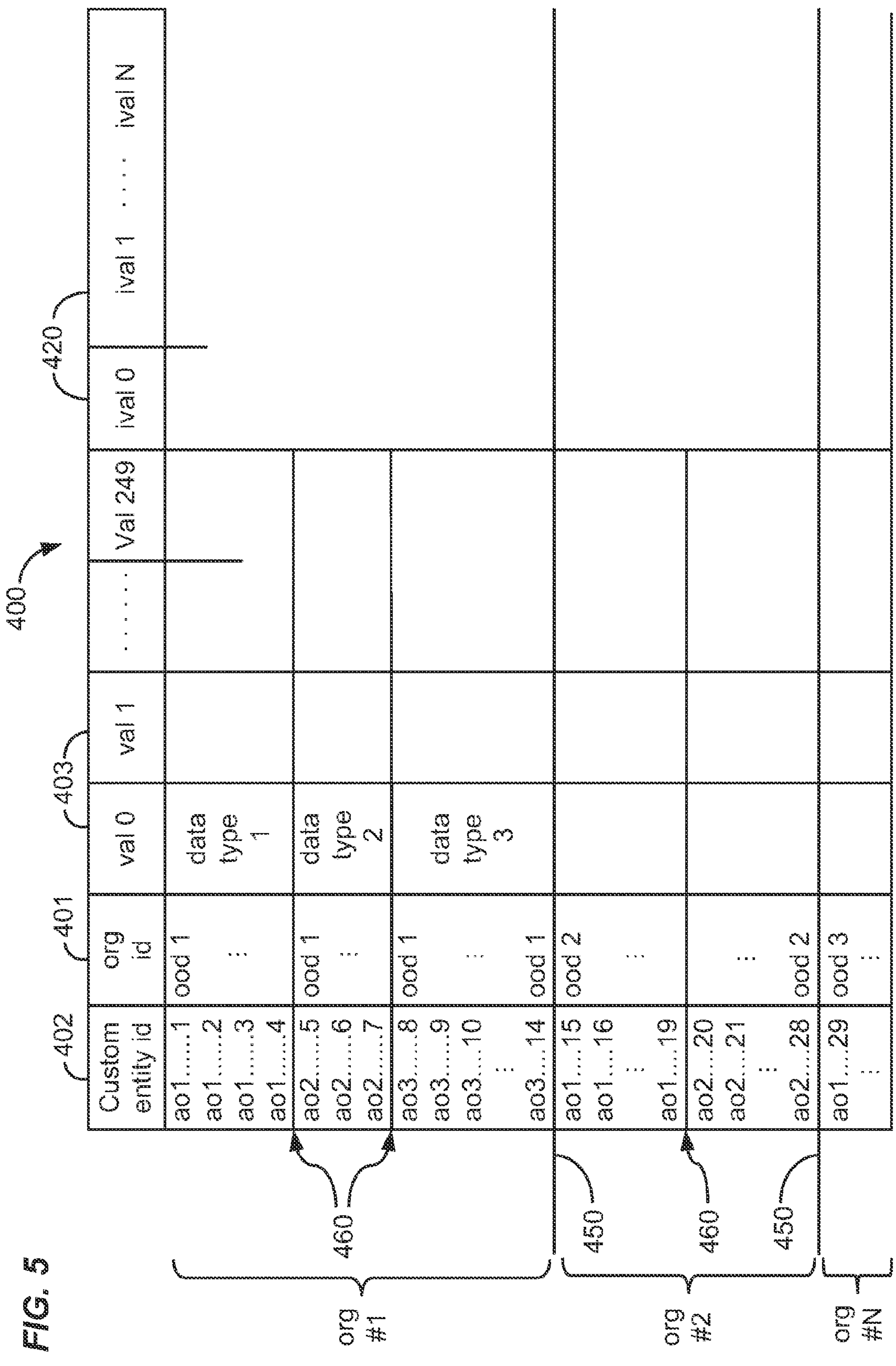

400
402
401
403
420
Custom entity id
org id
val 0
val 1
. . . . . .
Val 249
ival 0
ival 1
. . . .
ival N
ao1.....1
ao1.....2
ao1.....3
ao1.....4
ao2.....5
ao2.....6
ao2.....7
ao3.....8
ao3.....9
ao3....10
ao3....14
ao1....15
ao1....16
ao1....19
ao2....20
ao2....21
ao2....28
ao1....29
ood 1
ood 1
ood 1
ood 1
ood 2
ood 2
ood 3
data type 1
data type 2
data type 3
460
450
460
450
org #1
org #2
org #N

FIG. 5

500

Custom_field_definition

Custom_field_defn_id	Org_id	table name or id	field name	field data name	is_indexed	column-number
510	520	530	540	550	560	570

FIG. 6A

600

Custom_Entity_Definition

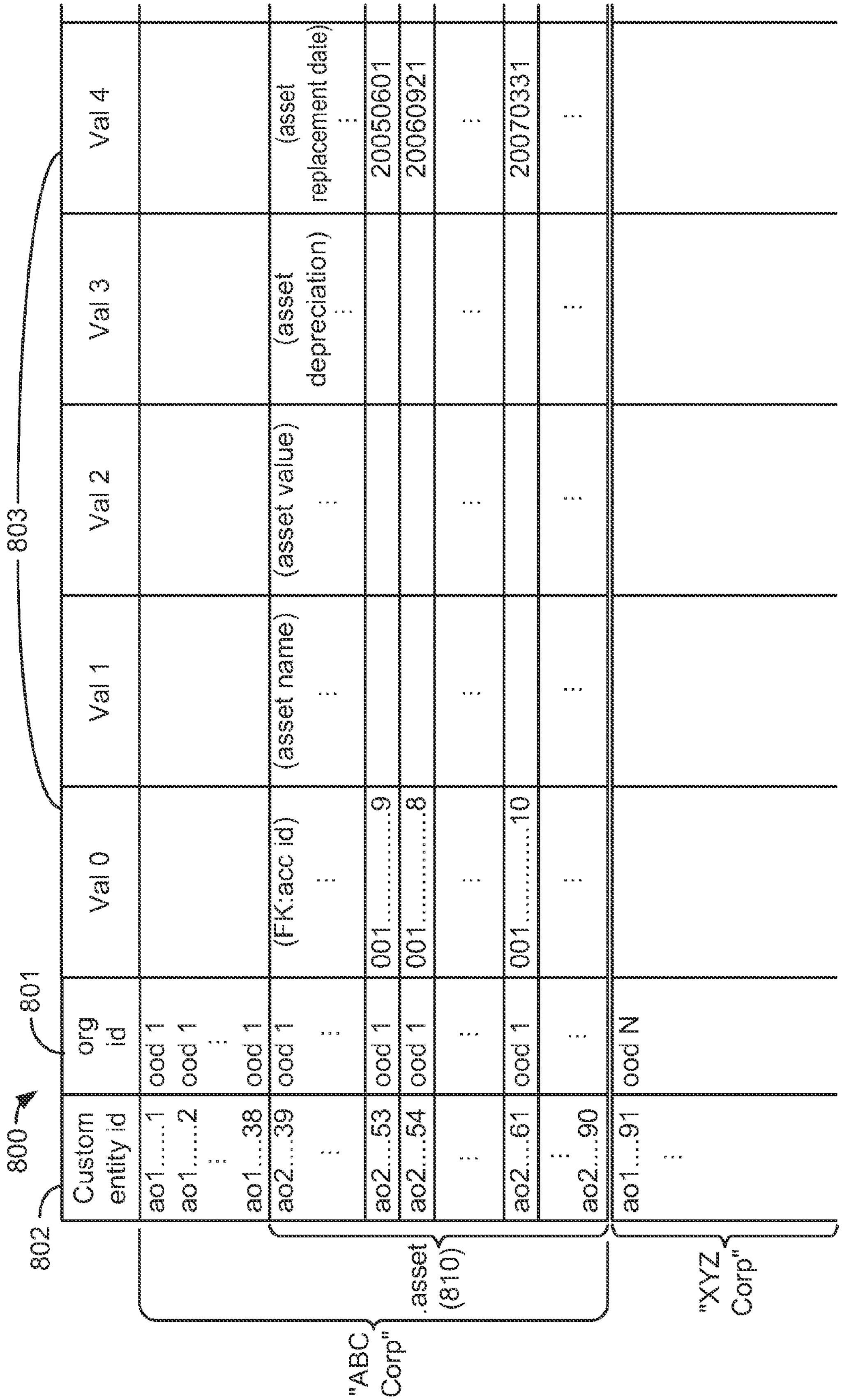
Custom_entity_defn_id	Org_id	entity_name	Key prefix
610	620	630	640

FIG. 6B

701 .account 702 703 711 .account_cfdata 713

	Org id	acc id	name	other standard fields	org id	acc id	Val 0	Val 1	Val 0
"ABC Corp"	ood 1 ⋮	oo1 1 oo1 2 ⋮	⋮	⋮	⋮	712	(web address)	(stock price)	(stock ticker)
	ood 1	oo1....8	IBM		ood 1	oo1....8	IBM.com	91.80	IBM
	ood 1	oo1....9	DELL		ood 1	oo1....9	DELL.com	33.47	DELL
	ood 1	oo1..10	APPLE		ood 1	oo1..10	Apple.com	26.03	AAPL
	ood 1	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
"123 Corp"	ood 2 ⋮	oo1..48 ⋮ oo1..86	⋮	⋮	⋮	⋮	(next annual mtg)	⋮	⋮
	ood 2	oo1..87	Disney		ood 2	oo1..87	20050220		
	ood 2	oo1..88	Pixar		ood 2	oo1..88	20040918		
	⋮ ood 2	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
"XYZ Corp"	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	ood N ⋮	oo1...919 ⋮ oo1...931		⋮	⋮	⋮	(Fiscal year)	⋮	⋮
	ood N	oo1...932	Disney		ood N	oo1...932	Q3		
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

FIG. 7



800
801
802
803
Custom entity id
org id
Val 0
Val 1
Val 2
Val 3
Val 4
(FK:acc id)
(asset name)
(asset value)
(asset depreciation)
(asset replacement date)
ao1.....1
ao1.....2
ao1....38
ao2....39
ao2....53
ao2....54
ao2....61
ao2....90
ao1....91
ood 1
ood N
001...............9
001...............8
001..............10
20050601
20060921
20070331
.asset (810)
"ABC Corp"
"XYZ Corp"

FIG. 8

CUSTOM ENTITIES AND FIELDS IN A MULTI-TENANT DATABASE SYSTEM

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 12/764,780, filed Apr. 21, 2010, by Craig Weissman et al., which is a continuation of U.S. patent application Ser. No. 10/817,161, filed Apr. 2, 2004, by Craig Weissman et al., and issued on Aug. 17, 2010 as U.S. Pat. No. 7,779,039. Both related patent applications listed hereinabove are hereby incorporated by reference in their entirety.

BACKGROUND OF THE INVENTION

The present invention relates generally to multi-tenant databases, and more particularly to systems and methods for creating custom objects, such as custom entities and fields, in a multi-tenant database system.

In multi-tenant database systems, such as the salesforce.com service, a multi-tenant architecture is used wherein customer organizations (i.e., tenants) share database resources in one logical database. The database tables themselves are typically shared; each entity in the data model typically contains an organization_id column that distinguishes rows for each tenant. All queries and data manipulation in the context of a tenant filter on this (indexed) organization_id column to ensure proper security and the appearance of virtual private databases. In the salesforce.com system, for example, this strategy is used to expose standard entities such as Account, Contact, Lead, and Opportunity entities to customers.

However, customers may wish to add their own custom data to the database system in addition to the standard entities and fields provided with the standard application. In a traditional client/server application, where the customer has its own physical database, adding custom data is typically done via DDL (data definition language) against that database to create new physical schema—tables and columns. In an online multi-tenant database system, such as the salesforce.com service, this approach may be untenable for various reasons. For example, for a database system with a large population of tenants (e.g., on the order of 1,000 or 10,000 or more tenants), the union of all desired schema would overwhelm the underlying data dictionary catalog (e.g., Oracle dictionary). Additionally, the maintenance of all of these schema objects would be a nearly impossible burden for DBAs (database administrators). Further, current relational databases do not support online DDL (in a highly concurrent transactional system) well enough for organizations to remain logically independent. Specifically, the creation of schema by one organization could lock the application for all other customers causing unacceptable delays.

Accordingly, it is desirable to provide systems and methods that offer a flexible approach to storing variable schema data in a fixed physical schema so as to overcome the above and other problems.

BRIEF SUMMARY OF THE INVENTION

The present invention provides novel systems and methods for hosting variable schema data such as dynamic tables and columns in a fixed physical database schema.

According to the present invention, standard objects, such as tables are provided for use by multiple tenants or organizations. Each organization may add or define custom fields for inclusion in a standard object. In one aspect, custom fields for multiple tenants are stored in a single field within the object data structure, and this single field may contain different data types for each tenant. Indexing columns are also provided, wherein a tenant may designate a field for indexing. Data values for designated fields are copied to an index column, and each index column may include multiple data types. Each organization may also define custom objects including custom fields and indexing columns. In one aspect, custom objects for multiple tenants are stored in a single custom object data structure. The primary key values for the single custom object table are globally unique, but also include an object-specific identifier which may be re-used among different entities.

An example computer-implemented method of storing multiple fields for multiple tenants in a single multi-tenant data structure, according to the disclosure, includes defining a multi-tenant data structure having a plurality of custom data columns, and defining a first data field for a first tenant. The first data field has a first data type. The method further includes defining a second data field for a second tenant. The second field has a second data type different than the first data type. The method further includes, when records having data values in the first and second fields are created by the first and second tenants, respectively, storing the data values of first and second fields to a single custom data column in the data structure. The single custom data column includes data values have different data types for different tenants.

The example computer-implemented method of storing multiple fields for multiple tenants in a single multi-tenant data structure can include one or more of the following features. Defining a separate data structure, and for each of the first and second fields, storing an indication of the corresponding data type in the separate data structure. The separate data structure has an organization id column, and the method further includes determining a tenant id for each of the first and second tenants, and for each of the first and second tenants, storing the respective tenant id in the organization id column of the separate data structure. Determining at least one of the first data field or the second field has been flagged for indexing, and storing, in the separate data structure, an indication that the at least one of the first data field or the second field has been flagged for indexing. Storing an indication of the data type corresponding to each of the first and second fields in extensible markup language (XML) format. The data values of first and second fields are stored in the single custom data column as text in a canonical format. Defining a separate data structure having one or more columns, and in response to an indication from one of the first tenant and the second tenant that data in the first data field or the second data field, respectively, be unique, copying the data values stored in the single custom data column corresponding to the first data field or the second data field, respectively, to a column in the separate data structure.

An example computer-readable medium storing code for controlling a database system to store multiple fields for multiple tenants in a single multi-tenant data structure, according to the disclosure, includes code having instructions to define a multi-tenant data structure having a plurality of custom data columns, and define a first data field for a first tenant where the first data field having a first data type. The code further has instructions to define a second data field for a second tenant where the second field having a second data type. The second data type is different than the first data type. Finally, the code further has instructions to, when records having data values in the first and second fields are created by the first and second tenants, respectively, store the data values of first and second fields to a single custom data column in the data structure. The single custom data column includes data values having different data types for different tenants.

The example computer-readable medium storing code for controlling a database system to store multiple fields for multiple tenants in a single multi-tenant data structure can further include code that provides one or more of the following features. Define a separate data structure, and, for each of the first and second fields, store an indication of the corresponding data type in the separate data structure. The separate data structure has an organization id column, and the code further has instructions to determine a tenant id for each of the first and second tenants, and for each of the first and second tenants, store the respective tenant id in the organization id column of the separate data structure. Determine at least one of the first data field or the second field has been flagged for indexing, and store, in the separate data structure, an indication that the at least one of the first data field or the second field has been flagged for indexing. Store an indication of the data type corresponding to each of the first and second fields in extensible markup language (XML) format. The data values of first and second fields are stored in the single custom data column as text in a canonical format. Define a separate data structure having one or more columns, and in response to an indication from one of the first tenant and the second tenant that data in the first data field or the second data field, respectively, be unique, copy the data values stored in the single custom data column corresponding to the first data field or the second data field, respectively, to a column in the separate data structure.

An example multi-tenant database system, according to the disclosure, includes a database for storing multi-tenant data objects, and a database management process. The database management process is configured to define a multi-tenant data structure having a plurality of custom data columns, and define a first data field for a first tenant where the first data field having a first data type. The database management process is also configured to define a second data field for a second tenant, where the second field having a second data type different than the first data type. Finally, the database management process is also configured to, when records having data values in the first and second fields are created by the first and second tenants, respectively, store the data values of first and second fields to a single custom data column in the data structure. The single custom data column includes data values having different data types for different tenants.

The example multi-tenant database system further can include a database management process further configured to provide one or more of the following features. Define a separate data structure, and for each of the first and second fields, store an indication of the corresponding data type in the separate data structure. The separate data structure has an organization id column and the database management process is further configured to determine a tenant id for each of the first and second tenants, and for each of the first and second tenants, store the respective tenant id in the organization id column of the separate data structure. Determine at least one of the first data field or the second field has been flagged for indexing, and store, in the separate data structure, an indication that the at least one of the first data field or the second field has been flagged for indexing. Store an indication of the data type corresponding to each of the first and second fields in extensible markup language (XML) format. The data values of first and second fields are stored in the single custom data column as text in a canonical format.

Reference to the remaining portions of the specification, including the drawings and claims, will realize other features and advantages of the present invention. Further features and advantages of the present invention, as well as the structure and operation of various embodiments of the present invention, are described in detail below with respect to the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an environment wherein a multi-tenant database system (MTS) might be used according to one embodiment.

FIG. **2** illustrates elements of an MTS and interconnections therein in more detail according to one embodiment.

FIG. **3** illustrates an example of objects represented as a standard main table and an associated custom field table according to an embodiment of the present invention.

FIG. **4** illustrates a custom object represented as a custom field table **310** including physical index columns **320** according to one embodiment.

FIG. **5** illustrates an example of a custom object represented as a custom entity table according to one embodiment.

FIG. **6***a* illustrates a custom field definition metadata table according to an embodiment of the present invention.

FIG. **6***b* illustrates a metadata table used to record the name and other information for each custom entity object defined for each organization according to an embodiment of the present invention.

FIG. **7** illustrates an example of a standard entity table including standard columns and custom field columns, as well as examples of actual data values for multiple fictitious organizations.

FIG. **8** illustrates an example of a custom entity object including a custom table having data values for a fictitious organization.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** illustrates an environment wherein a multi-tenant database system might be used. As illustrated in FIG. **1** (and in more detail in FIG. **2**) any user systems **12** might interact via a network **14** with a multi-tenant database system (MTS) **16**. The users of those user systems **12** might be users in differing capacities and the capacity of a particular user system **12** might be entirely determined by the current user. For example, where a salesperson is using a particular user system **12** to interact with MTS **16**, that user system has the capacities allotted to that salesperson. However, while an administrator is using that user system to interact with MTS **16**, that user system has the capacities allotted to that administrator.

Network **14** can be a LAN (local area network), WAN (wide area network), wireless network, point-to-point network, star network, token ring network, hub network, or other configuration. As the most common type of network in current use is a TCP/IP (Transfer Control Protocol and Internet Protocol) network such as the global internetwork of networks often referred to as the "Internet" with a capital "I," that will be used in many of the examples herein, but it should be understood that the networks that the present invention might use are not so limited, although TCP/IP is the currently preferred protocol.

User systems **12** might communicate with MTS **16** using TCP/IP and, at a higher network level, use other common Internet protocols to communicate, such as HTTP, FTP, AFS, WAP, etc. As an example, where HTTP is used, user system **12** might include an HTTP client commonly referred to as a "browser" for sending and receiving HTTP messages from an

HTTP server at MTS **16**. Such HTTP server might be implemented as the sole network interface between MTS **16** and network **14**, but other techniques might be used as well or instead. In some implementations, the interface between MTS **16** and network **14** includes load sharing functionality, such as round-robin HTTP request distributors to balance loads and distribute incoming HTTP requests evenly over a plurality of servers. Preferably, each of the plurality of servers has access to the MTS's data, at least as for the users that are accessing that server.

In preferred aspects, the system shown in FIG. **1** implements a web-based customer relationship management (CRM) system. For example, in one aspect, MTS **16** can include application servers configured to implement and execute CRM software applications as well as provide related data, code, forms, web pages and other information to and from user systems **12** and to store to, and retrieve from, a database system related data, objects and web page content. With a multi-tenant system, tenant data is preferably arranged so that data of one tenant is kept separate from that of other tenants so that one tenant does not have access to another's data, unless such data is expressly shared.

One arrangement for elements of MTS **16** is shown in FIG. **1**, including a network interface **20**, storage **22** for tenant data, storage **24** for system data accessible to MTS **16** and possibly multiple tenants, program code **26** for implementing various functions of MTS **16**, and a process space **28** for executing MTS system processes and tenant-specific processes, such as running applications as part of an application service.

Several elements in the system shown in FIG. **1** include conventional, well-known elements that need not be explained in detail here. For example, each user system **12** could include a desktop personal computer, workstation, laptop, PDA, cell phone, or any WAP-enabled device or any other computing device capable of interfacing directly or indirectly to the Internet or other network connection. User system **12** typically runs an HTTP client, e.g., a browsing program, such as Microsoft's Internet Explorer™ browser, Netscape's Navigator™ browser, Opera's browser, or a WAP-enabled browser in the case of a cell phone, PDA or other wireless device, or the like, allowing a user (e.g., subscriber of a CRM system) of user system **12** to access, process and view information and pages available to it from MTS **16** over network **14**. Each user system **12** also typically includes one or more user interface devices, such as a keyboard, a mouse, touch screen, pen or the like, for interacting with a graphical user interface (GUI) provided by the browser on a display (e.g., monitor screen, LCD display, etc.) in conjunction with pages, forms and other information provided by MTS **16** or other systems or servers. As discussed above, the present invention is suitable for use with the Internet, which refers to a specific global internetwork of networks. However, it should be understood that other networks can be used instead of the Internet, such as an intranet, an extranet, a virtual private network (VPN), a non-TCP/IP based network, any LAN or WAN or the like.

According to one embodiment, each user system **12** and all of its components are operator configurable using applications, such as a browser, including computer code run using a central processing unit such as an Intel Pentium processor or the like. Similarly, MTS **16** (and additional instances of MTS's, where more than one is present) and all of their components might be operator configurable using application(s) including computer code run using a central processing unit such as an Intel Pentium processor or the like, or multiple processor units. Computer code for operating and configuring MTS **16** to intercommunicate and to process web pages and other data and media content as described herein is preferably downloaded and stored on a hard disk, but the entire program code, or portions thereof, may also be stored in any other volatile or non-volatile memory medium or device as is well known, such as a ROM or RAM, or provided on any media capable of storing program code, such as a compact disk (CD) medium, digital versatile disk (DVD) medium, a floppy disk, and the like. Additionally, the entire program code, or portions thereof, may be transmitted and downloaded from a software source, e.g., over the Internet, or from another server, as is well known, or transmitted over any other conventional network connection as is well known (e.g., extranet, VPN, LAN, etc.) using any communication medium and protocols (e.g., TCP/IP, HTTP, HTTPS, Ethernet, etc.) as are well known. It will also be appreciated that computer code for implementing aspects of the present invention can be implemented in any programming language that can be executed on a server or server system such as, for example, in C, C++, HTML, Java, JavaScript, any other scripting language, such as VBScript and many other programming languages as are well known.

According to one embodiment, each MTS **16** is configured to provide web pages, forms, data and media content to user systems **12** to support the access by user systems **12** as tenants of MTS **16**. As such, MTS **16** provides security mechanisms to keep each tenant's data separate unless the data is shared. If more than one MTS is used, they may be located in close proximity to one another (e.g., in a server farm located in a single building or campus), or they may be distributed at locations remote from one another (e.g., one or more servers located in city A and one or more servers located in city B). As used herein, each MTS could include one or more logically and/or physically connected servers distributed locally or across one or more geographic locations. Additionally, the term "server" is meant to include a computer system, including processing hardware and process space(s), and an associated storage system and database application (e.g., RDBMS) as is well known in the art. It should also be understood that "server system" and "server" are often used interchangeably herein. Similarly, the databases described herein can be implemented as single databases, a distributed database, a collection of distributed databases, a database with redundant online or offline backups or other redundancies, etc., and might include a distributed database or storage network and associated processing intelligence.

FIG. **2** illustrates elements of MTS **16** and various interconnections in more detail. In this example, the network interface is implemented as one or more HTTP application servers **100**. Also shown is system process space **102** including individual tenant process spaces **104**, a system database **106**, tenant database(s) **108** and a tenant management process space **110**. Tenant database **108** might be divided into individual tenant storage areas **112**, which can be either a physical arrangement or a logical arrangement. Within each tenant storage area **112**, user storage **114** might similarly be allocated for each user.

It should also be understood that each application server **100** may be communicably coupled to database systems, e.g., system database **106** and tenant database(s) **108**, via a different network connection. For example, one server $\mathbf{100}_1$ might be coupled via the Internet **14**, another server $\mathbf{100}_{N-1}$ might be coupled via a direct network link, and another server $\mathbf{100}_N$ might be coupled by yet a different network connection. Transfer Control Protocol and Internet Protocol (TCP/IP) are preferred protocols for communicating between servers **100** and the database system, however, it will be apparent to one skilled in the art that other transport protocols may be used to optimize the system depending on the network interconnect used.

In preferred aspects, each application server **100** is configured to handle requests for any user/organization. Because it is desirable to be able to add and remove application servers from the server pool at any time for any reason, there is preferably no server affinity for a user and/or organization to a specific application server **100**. In one embodiment, therefore, an interface system (not shown) implementing a load balancing function (e.g., an F5 Big-IP load balancer) is communicably coupled between the servers **100** and the user systems **12** to distribute requests to the servers **100**. In one aspect, the load balancer uses a least connections algorithm to route user requests to the servers **100**. Other examples of load balancing algorithms, such as round robin and observed response time, also can be used. For example, in certain aspects, three consecutive requests from the same user could hit three different servers, and three requests from different users could hit the same server. In this manner, MTS **16** is multi-tenant, wherein MTS **16** handles storage of different objects and data across disparate users and organizations.

As an example of storage, one tenant might be a company that employs a sales force where each salesperson uses MTS **16** to manage their sales process. Thus, a user might maintain contact data, leads data, customer follow-up data, performance data, goals and progress data, etc., all applicable to that user's personal sales process (e.g., in tenant database **108**). In the preferred MTS arrangement, since all of this data and the applications to access, view, modify, report, transmit, calculate, etc., can be maintained and accessed by a user system having nothing more than network access, the user can manage his or her sales efforts and cycles from any of many different user systems. For example, if a salesperson is visiting a customer and the customer has Internet access in their lobby, the salesperson can obtain critical updates as to that customer while waiting for the customer to arrive in the lobby.

While each user's sales data might be separate from other users' sales data regardless of the employers of each user, some data might be organization-wide data shared or accessible by a plurality of users or all of the sales force for a given organization that is a tenant. Thus, there might be some data structures managed by MTS **16** that are allocated at the tenant level while other data structures might be managed at the user level. Because an MTS might support multiple tenants including possible competitors, the MTS should have security protocols that keep data, applications and application use separate. Also, because many tenants will opt for access to an MTS rather than maintain their own system, redundancy, up-time and backup are more critical functions and need to be implemented in the MTS.

In addition to user-specific data and tenant-specific data, MTS **16** might also maintain system level data usable by multiple tenants or other data. Such system level data might include industry reports, news, postings, and the like that are sharable among tenants.

In certain aspects, client systems **12** communicate with application servers **100** to request and update system-level and tenant-level data from MTS **16** that may require one or more queries to database system **106** and/or database system **108**. MTS **16** (e.g., an application server **100** in MTS **16**) generates automatically one or more SQL statements (the SQL query) designed to access the desired information.

Each database can generally be viewed as a collection of objects, such as a set of logical tables, containing data fitted into predefined categories. A "table" is one representation of a data object, and is used herein to simplify the conceptual description of objects and custom objects according to the present invention. It should be understood that "table" and "object" may be used interchangeably herein. Each table generally contains one or more data categories logically arranged as columns or fields in a viewable schema. Each row or record of a table contains an instance of data for each category defined by the fields. For example, a CRM database may include a table that describes a customer with fields for basic contact information such as name, address, phone number, fax number, etc. Another table might describe a purchase order, including fields for information such as customer, product, sale price, date, etc. In some multi-tenant database systems, standard entity tables might be provided. For CRM database applications, such standard entities might include tables for Account, Contact, Lead and Opportunity data, each containing pre-defined fields.

Custom Fields

According to one embodiment, for a table such as one for a standard entity, an additional set of one or more columns, e.g., 10, 100, or 250 columns, of text data are defined in the physical schema. These additional columns, also referred to herein as custom data columns, custom field columns or custom fields, allow a system administrator to define additional fields that are not included in the pre-defined standard fields for that entity. These custom fields preferably have a data-type of VARCHAR (variable length character). In one aspect, these custom fields are preferably stored out of row from the main entity table, although these fields may be stored in the main table. For example, if the main table is called "sales.account" then the custom field data might be stored in a table called "sales.account_cfdata" where "cf" stands for "custom field." Both of these tables preferably contain an organization_id column to distinguish tenant rows, as well as the same indexed primary key (e.g., account id, in this case) that identifies those rows throughout the database. Furthermore, both tables are preferably partitioned physically on the DB (e.g., Oracle DB) to encourage parallelization, for example, when necessary to act on the entire table for maintenance purposes and to maintain shallower indexes.

FIG. **3** illustrates an example of objects represented as a main table **200** and an associated custom field table **210**. In the specific example shown in FIG. **3**, the main table **200** (.account) represents a standard Account entity and the custom field table **210** (.account_cfdata) includes the custom fields defined by the various organizations (tenants) using the main table **200**. As shown, main table **200** includes an organization ID ("org id") column **201** and a table ID (e.g., "acc id" for .account id) column **202** that acts as the primary key for table **200**. Data table **200** also includes a plurality of data columns **203**. In the specific example of FIG. **3**, where the table represents a standard entity, data columns **203** are the predefined data columns, or standard fields, that are provided to the various organizations that might use the table. In the standard Account entity example, such standard fields might include a name column, a site column, a number of employees column and others as would be useful for storing account-related information. Each of the data columns **203** is preferably defined to store a single data type per column. The org id column **201** is provided to distinguish among organizations using the multi-tenant account table **200**. As shown, N different organizations have data stored in table **200**. The org ids in column **201** are preferably Char(15), but may include other data types. In one aspect, the first 3 characters of the org id is set to a predefined prefix, such as "00d", although another subset of characters in the org id may be used to hold such a prefix if desired.

Custom field table **210** similarly includes an org id column **211**, a table id column **212** and plurality of data columns **213**. As above, table id column **212** acts as the primary key for table **210** and preferably includes the same values as table id column **202** of table **200**. In the specific example shown, there are 250 data columns **213** labeled as val**0**, val**1** . . . val**249**. It is appreciated that any other number may be used as desired, such as, for example, 10 or 100.

When an organization is created initially and associated with database table **200**, the custom field columns **213** are empty for that organization. However, every time a record or row is created in the main table (e.g., .account) a corresponding row is created in the custom field table—all custom field columns are Null, and therefore take up no space until used.

In one aspect, data is only allowed to enter these custom fields when a new "column" for the organization is defined, e.g., by the administrator for that organization. For example, in the Account entity example, it may be desirable for a specific organization to create one or more additional custom fields, in addition to the standard fields **203**, to store specific types of data that may not be accounted for in the predefined standard fields. The present invention advantageously allows an organization to create additional custom columns for such data. Rather than defining a physical column (in Oracle, the definition of which would be placed in the Oracle dictionary catalog) instead this definition is stored in metadata, e.g., in a metadata catalog, which may include one or more metadata tables. The definition of a physical column could likewise be stored in XML or some other format.

FIG. **6***a* illustrates an example of a custom field definition metadata table **500** ("custom_field_definition") according to an embodiment of the present invention. Custom_field_definition metadata table **500** is used to record the name, datatype and other information for each custom field column defined for each organization and table (e.g., standard tables and custom tables, which will be described in more detail below). As shown, metadata table **500** includes custom_field_definition_id column **510**, organization_id column **520**, table name or id column **530**, field name column **540**, field datatype column **550**, is_indexed column **560** and a column_number column **570**. Organization_id column **520** stores the org id of the organization for which the custom field is created, and the custom_field_definition_id column is the primary key for table **500**. Table name column **530** stores the names of standard entity tables, such as Account, or the id of custom entity tables created for an organization. Field name column **540** stores the text name of the custom field, and field datatype column **550** stores the data type for the custom field. Examples of data types include text, number, date, picklist, etc. A picklist data type is a text field where the value is chosen from an enumerated list of values. A picklist is typically displayed as a dropdown in the UI. Is_indexed column **560** stores a value indicating whether the field has been flagged for indexing, which will be described in more detail below. In one aspect, column **560** stores a boolean value. Column_number column **570** stores the column number (e.g., "val**0**") assigned to a custom field in custom field table **210** (FIG. **3**).

The creation of a new custom field in the application allocates one of the custom field columns **213** to hold the data. In preferred aspects, the lowest numbered columns are filled first. For example, as shown in FIG. **3**, the "val**0**" column is filled first and then the "val**1**" column and so on for each organization. Therefore, depending on the number of custom columns defined by an organization, each custom field **213** may or may not contain data for an organization. Now, when users of the application in an organization edit rows for that table, the new custom field appears on the screen (or via the API), which will appear the same as all the other standard fields. However, when this data is persisted in the database, the value of the custom field is stored in the designated custom field column in the separate custom field table **210**, instead of in the standard main table **200**.

In one aspect, a variety of virtual data-types are allowed for these custom fields even though the underlying physical storage may be character based. When the organization's system administrator defines numeric or date custom field types, for instance, then the values are stored as text in a canonical format that allows easy conversion back to the logical datatype. As mentioned earlier, in one aspect, a data type of VARCHAR is preferably used. For instance, in this aspect, dates are stored in the YYYYMMDD format—which allows for conversion via the TO_DATE(<column>, 'YYYYMMDD') function and also allows for proper sorting without doing any conversion. For numbers, the usual decimal format is used, and the Oracle function TO_NUMBER( ) may be used to convert back to numeric values for sorting, mathematical operations, and filtering, etc.

Because the database is multi-tenant, a given physical custom field column may contain data across multiple organizations. For example, because an organization is not limited to specific data types, one organization may define one data type such as a date and another organization may define a different data type such as a string or a number. Therefore it is likely that strings, numbers, and dates will all be found in one physical custom field column. FIG. **3** illustrates an example of a custom field column containing different data types. As shown in the "val**0**" custom column, for example, the custom column data type defined by organization **1** is data type **1**, the custom column data type defined by organization **2** is data type **2**, and the custom column data type defined by organization N is data type **3**. Data types **1**, **2** and **3** may be the same or they may be different. For example, data type **1** may be text, data type **2** may be date, and data type **3** may be number. FIG. **7**, and the related discussion below, illustrates an example where different data types are mixed in a custom field column. In one aspect, a separate pool of columns is provided for custom fields of different data types, i.e., each of the custom field columns in the separate pool contains a single data type.

In one embodiment, metadata is used to determine the data type(s) in a given custom field column. That is, metadata is used to track the logical data type for each organization in each custom column. In one aspect, a mapping function is created from the metadata. For example, when an organization defines a custom field for a standard entity, a custom field definition is stored in metadata table **500** including the organization id for that organization, the table name (e.g., .account_cfdata) and the column number assigned in the custom table (e.g., val**0**). In this manner, the data type(s) in any custom column can be determined for efficient data retrieval given the column number, table name and organization id.

Custom Field Indexing

Now consider the problem of indexing the data in these custom field columns (e.g., columns **213**) to allow for fast retrieval. For example, users expect to filter on date values as dates and numeric values as numbers. However, in order for these filters to work efficiently, given the expressions above used to convert their values, it would be necessary to place a functional index (e.g., an Oracle DB functional index) on each organization's slice of the data in a given custom field column. This is not possible from the Oracle DB perspective because the Oracle DB does not understand that one physical column contains data in multiple formats. For example, if one tries to create an index on the TO_DATE or TO_NUMBER expressions above, an error would result since other textual values in that physical column would not conform to the desired format.

Similarly, when searching on string data, users expect case insensitive searches. That is, searching for "car" should find "CAR" or "CaR." However, the definition of case insensitive is language dependent, and a service (e.g., CRM service) using such a multi-tenant database structure may be multi-language enabled. To search properly on multi-language data requires the use of a functional index built using various NLS (natural language standards) functions in Oracle. Since a given physical column could contain data in multiple languages it would be necessary to build N different indexes for each of the languages supported which would result in a non-scalable solution.

For the reasons listed above, such "Indexed Custom Fields" are implemented in one embodiment by storing data in a separate set of indexed columns. According to one embodiment of the present invention, a plurality of additional index columns are provided to allow for indexing custom fields. When a custom field is flagged for indexing by a database administrator, one of the plurality of index columns is allocated to that flagged column. Data from the flagged column is copied to the allocated index column. The data is stored in the index column in a format that facilitates searching, e.g., for dates and strings. For example, the YYYYMMDD is itself a searchable format as strings in that format can be compared lexically using normal string comparison.

FIG. **4** illustrates an example of a custom object represented as a custom field table **310** including physical index columns **320** according to one embodiment. In one aspect, each custom field data table contains multiple (e.g., 10, 100, 250, etc.) physically indexed columns **320**, e.g., using standard Oracle B*Tree indexes. In an example with 10 indexed columns, an administrator can therefore designate up to 10 custom fields, of string or date types, to be indexed. When a custom field is flagged for indexing, the data in the original column (which is still maintained to display the un-modified format to the user when necessary) is copied to one of these indexed columns. For example, as shown in FIG. **4**, custom data field "val**0**" was flagged by the system administrator for organization **1** as an indexed custom column. Data from this flagged column is copied to the index column "ival**0**". Similarly, custom data field "val**1**" was flagged by the system administrator for organization **2** as an indexed custom column, and the data from this flagged column is copied to index column "ival**0**". At some later time, the system administrator for organization **2** may have flagged another custom field column and the data for this column is copied to another index column (e.g., column "val**0**" data copied to column "ival**1**" as shown in FIG. **4**). In one aspect, similar to the custom fields, the lowest numbered index columns are preferably used or filled first.

In one aspect, to avoid the problem with searching across multiple languages, a "case folding" algorithm is implemented (e.g., in an application server) that converts each string custom field value to a universal case insensitive format. One such case folding algorithm is an algorithm defined by the Unicode Consortium in the Unicode 4.0 standard, section 3.13-Caseless Matching (http://www.unicode.org/versions/Unicode4.0.0/ch03.pdf), hereby incorporated by reference, which is a tabular lookup function that converts characters to a form that is binary comparable independent of case for all languages that have a concept of case. Whenever values in the original custom field column are searched, the SQL instead filters on the corresponding case-folded indexed column after performing the same case folding operation on the literal being searched. Dates need not be modified from their YYYYMMDD format, which is also included in the index (unmodified) as text.

Organizations that choose not to use indexed custom fields will have null values in these fields, and Nulls do not take up any space in the indexes. In this manner space is used up in the database only as custom columns are actually indexed. Also, index columns **320** are preferably stored in the corresponding custom field table, however, they may be stored out of row, in which case it is preferred that the org id **311** and table id **312** columns be copied to the separate indexed column table to facilitate searching.

Custom Field Uniqueness

Another desired schema feature is the concept of a uniqueness constraint. Again, a unique index cannot be placed on a custom field physical column because, although the values may be unique for one organization, they may not be unique for some other organization that shares that physical column. For example, it is possible that two records for two different organizations would have the same exact data value stored in the same custom field.

To implement this uniqueness feature, in one aspect, a separate table is provided that contains only the data values for customers who require uniqueness. Once the organization administrator has enabled a custom field for uniqueness, all values for that organization are inserted in this unique index table, and ongoing changes to that custom field column are updated synchronously to the unique index table (described below). If either of these operations causes an Oracle DB unique index violation then the error is passed back to the end user—the administrator would need to "clean up" the data in a field before declaring it unique.

One schema for a unique index maintenance table is as follows:

1. organization_id
2. custom field_definition id
3. custom field value

This schema allows multiple custom fields from the same organization (and entity) to be indexed. The first two columns are preferably compressed in the Oracle DB unique index since that would make the physical index smaller, and this table could be index organized since its only purpose as a table is to be used as a unique index.

Custom Tables

It is also desirable to create whole new logical entity tables (entities) for the purpose of extending a base application or for integrating with other systems. For example, an organization using the standard entities provided by the system may desire that one or more new entities be created to specifically cater to, and to facilitate data storage and retrieval for, that organization's particular business model. Accordingly, one embodiment of the present invention provides the functionality to create custom entity tables or custom entities.

As with the approach for custom fields, all custom entity data rows are stored in a single multi-tenant physical table according to one embodiment. However, unlike standard custom field tables, the custom entity data table in one aspect contains multiple logical tables per organization. It is transparent to customers that their multiple "tables" are in fact stored in one large table.

FIG. **5** illustrates an example of a custom object represented as a custom entity table **400** according to one embodiment. Table **400** includes an org id column **401**, a custom entity id column **402** and a plurality of custom field columns **403** (labeled "val**0**", "val**1**", . . .). A plurality of optional index columns **420** (labeled "ival**0**", "ival**1**", . . .) may also be provided. The org id column is used to distinguish among the various organizations populating table **400**. For example, multiple organizations may create custom entities, all of which are stored to table **400** in one aspect. Custom entity id column **402** is used to distinguish among the various custom entity tables stored in table **400**. Custom entity id column **402** also acts as the primary key column for table **400**. Custom field columns **403** are used to store the data for the various custom entities defined by the various organizations. Specifically, custom field columns **403** store the columns defined for each of the various custom entities defined by the various organizations populating table **400**. Index columns **420** are implemented similar to custom field indexed columns **320** described above with reference to FIG. **4**.

According to one embodiment, the first 3 characters of the globally unique primary key field **402** are used to identify the specific entity type. This technique advantageously allows for multiple custom entity types for one organization to be distinguished in this one custom entity table **400** as will be discussed below. It will be appreciated, however, that fewer or more than the first 3 characters of the primary key may be used to identify entities, or that any subcombination of characters of the primary key may be used.

When an organization administrator defines a new custom entity, the definition is stored in the metadata instead of the underlying data dictionary. FIG. **6***b* illustrates an example of a custom entity definition metadata table **600** ("custom_entity_definition") according to an embodiment of the present invention. When a new custom entity is defined, the database system allocates a unique (within that organization) 3-character prefix for rows of that entity type. In one aspect, the letter 'a' is chosen as the first character of all custom entity primary keys, e.g., a01 . . . a02 . . . a03 . . . aMN . . . as shown in column **402** of table **400**. As shown, across all organizations the same 3-character prefix may be re-used. For example, "a01" is reused as a prefix for multiple organizations. However, the remainder of the custom entity id ensures global uniqueness (and that data from different organizations is never mingled). In one aspect, these 3-character id's are encoded in base 62, so that each initial character allows for 62*62=3844 different custom entity types per organization—a large enough number for virtually all uses. It should be appreciated, however, that different encoding bases may be used to provide a fewer or greater number of custom entity types per organization. It should also be appreciated that the entity id field may be a composite primary key, for example, spanning two or more columns, one column for the prefix and the other column(s) for the remainder of the custom entity id. For the sake of simplicity, row partitions are not shown in table **400**, however organization partitions **450** and entity partitions **460** are shown.

Referring to FIG. **6***b*, custom_entity_definition metadata table **600** is used to record the name and other information for each custom entity object defined for each organization. As shown, metadata table **600** includes custom_entity_definition_id column **610**, organization_id column **620**, entity_name column **630**, and key prefix column **540**. Organization_id column **620** stores the org id of the organization for which the custom entity is created, and the custom_entity_definition_id column **610** is the primary key for table **600**. Entity name column **630** stores the names of the custom entity table, e.g., as a text datatype. Key prefix column **640** stores the 3-character prefix (e.g., "a01", "a02", etc.) allocated for rows of that entity type.

When creating a custom entity table, the administrator for an organization specifies a unique (within the organization) developer name for the custom entity—this is the name used to identify that particular entity for API calls and other developer entry points into the system. This name is stored in the entity name column **630** of table **600**. Custom fields may also be defined for custom entities, and where desired, custom fields may be flagged for indexing, as described above. Once custom fields are defined for the custom entity, the organization can begin to use that custom entity like any other standard entity. For example, all API operations (e.g., describe, insert, update, delete, query, search) are available and the organization may define a user interface for editing that custom entity in an online application. Transparent to the users and organization, however, the custom entity table is stored in a single custom entity table **400** along with other custom entity tables defined by that organization as well as other organizations.

One difference in terms of SQL when operating on a custom entity table is the need to filter on the custom entity id in addition to the organization id to ensure that the data from multiple logical entity types within one organization are not mixed together. For example, the leading 3-character portion of the primary key index (e.g., a01 . . . aMN) can be used for this efficient filtering. Thus, filtering on the organization id and the 3-character prefix provides a determination of a specific entity type for the organization. Similarly, an insert PL/SQL call should be told which 3-character prefix to use when inserting a new primary key value and custom entity row.

Similar to custom field columns **213** of FIG. **3**, custom field columns **403** may contain multiple data types. For example, when organization #1 defines custom entity table **1** (identified by "a01" for org **1** "00d1" in table **400**) a custom field column definition having data type **1** may be allocated to the "val**0**" column as shown. Similarly, a custom field column definition for a second custom entity table (identified by "a02" for org **1**) having data type **2** may be allocated to the same "val**0**" column as shown. Data types **1** and **2** may be the same or different. In this manner, it is possible that numerous data types may be stored in any given custom field column **403** in custom entity table **400** for the various custom entities defined by the various organizations. Accordingly, using optional index fields **420**, an organization is able to flag one or more columns in its custom entities for indexing as described above. Filtering would also proceed similar to that discussed above.

In one embodiment, foreign keys may be defined as a data type when creating custom entities. In this manner a relationship with a standard entity, or another custom entity may be provided to facilitate data storage and retrieval (e.g., reduce redundant data storage). For example, when defining a custom entity, a system administrator may define a custom field as a foreign key data type to establish a relationship with one or more other entities. The primary key for the related entity is copied and stored in that custom field. In one aspect, a plurality of columns is provided to store custom fields of type foreign key. These separate columns may be indexed.

Specific Examples

FIG. **7** illustrates an example of a standard entity table **700** including standard columns **703** and custom field columns **713**, as well as examples of actual data values for multiple organizations. As shown, the standard table **700** represents an Account entity having a standard name field and other standard fields **703**. In this example, ABC Corp. (identified by "00d1" in org id field **701**) has defined a custom column for "account web address" that has been allocated to the val**0** column. The data type for this custom field is defined as text. Additionally, ABC Corp. has defined a second custom field for "account stock price", which has been allocated to the val**1** column, and a third custom field for "account ticker symbol", which has been allocated to another column. The data types for these columns are number and text, respectively. Similarly, 123 Corp. (identified by "00d2" in org id field **701**) and XYZ Corp. (identified by "00dN" in org id field **701**) have each defined a custom field for "account next annual meeting date" and "account fiscal year", respectively. The data types for these custom fields are date and picklist, respectively. These custom fields have both been allocated to the val**0** column, even though their data types are different. The definitions of these custom fields are stored to metadata, e.g., metadata table **500**, as discussed above.

As shown, table **700** holds account data for ABC Corp. including specific account data for "IBM", "Dell" and "Apple" as shown. Similarly, table **700** also holds account data for 123 Corp. and XYZ Corp. As shown, both 123 Corp. and XYZ Corp. each have a specific entry for an account with the same name: "Disney". However, these entries are distinguished based on the globally unique primary key **702** (or **712**). For example, for XYZ Corp., the account entry for "Disney" has a primary key value of "001 . . . 932", whereas the "Disney" account entry for 123 Corp. has a primary key value of "001 . . . 87". As above, the data values in the val**0** custom column have mixed data types. For example, for ABC Corp. the "web address" field is text, whereas the "next annual meeting date" field for 123 Corp. has a date data type, and the "fiscal year" field for XYZ Corp. has a picklist data type.

FIG. **8** illustrates an example of a custom entity object **800** including an custom table **810** for ABC Corp. As shown, ABC Corp. (identified by "00d1" in org id column **801**) has defined a custom object **810** to represent Assets. The definition of Assets object **810** is stored to metadata, e.g., in table **600** (FIG. **6***b*). Assets object **810** has been allocated the prefix "a02" for the custom entity id. Also, as shown, ABC Corp. has defined another custom object, e.g., identified by prefix "a01" in custom entity id column **802**. A separate column may be provided in table **800** to store the prefixes (e.g., "a01") of the various objects stored in table **800**. Assets object **810** has been defined with a custom foreign key column and various data columns. The custom foreign key (FK) column is allocated to the "Val**0**" column, whereas data fields for "asset name", "asset value", "asset depreciation type" and "asset replacement date" have been allocated to columns "Val**1**" to "Val**4**", respectively. In this example, the data types for these fields are text, number, picklist and date, respectively.

Assets object **810** is a child custom object of Account object **700**. The custom foreign key column connects each row in object **810** to its parent account (in these examples, Account object **700** has been allocated a prefix of "001" for its table id). For example, the foreign key value "001 . . . 9" connects to the row in table **700** for account name "DELL". Similarly, the foreign key values "001 . . . 8" and "001 . . . 10" connect to the rows in table **700** for account names "IBM" and "APPLE", respectively. Also, as shown, XYZ Corp. (identified by "00dN" in org id column **801**) has defined a custom object to suit their business needs, which custom object is also stored in table **800**. As such, any given data column **803** may contain mixed data types depending on the definitions of the various custom objects stored in table **800**.

Re-usable Services

One goal of custom entities is not only to support a grid of data (e.g., rows and columns configured by organizations/customers) but also to support the same set of application high-level semantic services exposed for standard entities. This provides for a system that is not only more than just an online data provider, but also an application-building infrastructure with rich re-usable services.

With reference to the salesforce.com service, several examples of such reusable services, and how they apply to custom entities, follow:

History Tracking

Standard entities in salesforce.com (such as Case and Opportunity entities) support automatic auditing of data changes to records. This auditing typically occurs at a low-level in the application server where all data is being written to the database. This same code path is preferably used with custom entities.

The same generalized schema used for standard entities works for custom entities as well—this is preferably a pivoted schema with one field delta per row:

1. organization_id
2. custom entity data id
3. custom field definition id
4. old value
5. new value.

However, it may be a non-pivoted schema. A non-pivoted schema has columns for each separate piece of information. It looks like an excel spreadsheet:

ID	Name	Phone	Email address
111	Craig	555-1212	foo@bar.com

A pivoted schema uses generic column names such as:

ID	Property Name	Property Value
111	Name	Craig
111	Phone	555-1212
111	Email Address	foo@bar.com

The pivoted schema has many more rows in it, but the rows are skinnier (imagine if there were 50 columns of data—that would turn into 50 rows in the pivoted schema, but the pivoted schema itself would have the same columns). So a normal schema is short and wide, whereas a pivoted schema is tall and skinny. A pivoted schema is useful, for example, for auditing purposes such as for providing a case history related list—where the user is shown every field value change as one row in a grid. Pivoted schemas, however, are typically difficult to use for normal data display like a detail screen with all the information for a person.

If the administrator "turns on" this property in the definition of the custom entity and custom field then this behavior happens automatically (changes are logged to this one multi-tenant auditing table). The data in this generic history table is available for display in the online application or via an API query.

As an example, consider changes made to a standard entity such as Case. The system might record the following history rows when edits to Case are saved:

Org Id	Case Id	Field Name	Old Value	New Value	Date
00d1	5001	Subject	Problem with Disc drive	Problem with Disk Drive	Mar. 4, 2004
00d1	5001	Status	Open	In Progress	Mar. 4, 2004
00d1	5001	Priority	Low	Medium	Mar. 4, 2004
00d1	5002	Status	Open	Closed	Mar. 5, 2004
00d1	5002	Rep Name (custom)	Frank	Sally	Mar. 5, 2004

The above data records two edit operations, one for case 5001 that occurred on Mar. 4, 2004, and another for case 5002 that occurred on Mar. 5, 2004. Several fields were edited each time.

As another example, consider changes made to the Assets custom object **810** of FIG. **8**. An example of history tracking rows for a single edit operation made on Mar. 4, 2004 might look like the following:

Org Id	Cust Ent Id	Field Name	Old Value	New Value	Date
00d1	a02	Asset Name	Laptop X	Laptop Y	Mar. 4, 2004
00d1	a02	Asset Value	50	45	Mar. 4, 2004
00d1	a02	Deprec. Type	Linear	Accelerated	Mar. 4, 2004

All this information is recorded automatically by the system. The user interface (UI) might present the information similar to that shown above, or in any other convenient format.

Permission Based Security and Sharing Model

Administrators may wish to restrict access to particular entity types from particular user profiles—in the same way that standard entities have permissions such as EDIT_ACCOUNT.

The administrator can define that a given entity type requires an explicit READ or EDIT permission. A generic profileCustomEntity metadata table (available for edit through the API) allows creation of relationship rows that associate a profile (read access) with a custom entity type and optionally declares whether users in that profile can edit rows in that entity type.

The common Application Server and PL/SQL code that retrieves and edits custom entity data can then check this metadata for the current user and reject the operation if the user does not have the proper permission.

In one aspect, a sharing model allows even finer granularity of access to rows—in addition to the permission checks above. The administrator, when defining a custom entity type, can choose whether the entity type is editable by all users (Public Read/Write), read-only for all users (Public Read/Only), or privately available only to the owner of a record or to users who are granted explicit sharing access to a record (Private).

To support the latter sharing model, in one aspect, a standard owner field is added to the custom entity data table and becomes available in the API. The same semantics attached to the owner field in other standard entities apply. For example, managers in the role hierarchy gain access to all records owned by a subordinate. Also, a generic sharing entity, e.g., customEntityShare, is used in one aspect for entering manual explicit sharing access for particular custom entity rows to users or groups—in the same way that the accountShare entity is available in the API (and UI) to allow granting explicit account access.

Currency Type

A standard field in custom entities is a single currency type that controls the currency of all numeric currency custom fields in that row. This functionality is consistent with all standard entities and allows for the same currency translation as elsewhere in the application.

Multiple Business Processes per Entity Type

Standard entities allow for the definition of multiple "Record Types" or business processes. For instance, an opportunity entity can have both telesales opportunities as well as direct sales opportunities. Depending on the record type of an individual opportunity row, the values available for picklist fields change as configured by the organization administrator.

Custom entities also allow for the specification of this same metadata by the administrator. The picklist custom fields in that entity are preferably affected in the same manner as for standard entities.

Workflow

In one aspect, the present invention provides for the definition of trigger conditions and actions for specific entity types. For instance, if an opportunity amount exceeds a particular value (trigger condition) then a notification, such as an email, is sent (action) to a predesignated individual or group, e.g., the VP of sales of that organization.

Once again the metadata used internally for defining these rules preferably operates similarly for custom entities as for standard entities. The code, e.g., executing in an application server or database server, that evaluates these conditions for each row edit occurs at a low level where both standard and custom entities are able to take advantage of this functionality.

While the invention has been described by way of example and in terms of the specific embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. To the contrary, it is intended to cover various modifications and similar arrangements as would be apparent to those skilled in the art. Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.

What is claimed is:

1. A computer-implemented method of storing multiple fields for multiple tenants in a single multi-tenant data structure, comprising:

defining a multi-tenant data structure having a plurality of custom data columns and at least one organization identifier (ID) column that stores a tenant ID value;

defining a first data field for a first tenant, the first data field having a first data type;

defining a second data field for a second tenant, the second field having a second data type, wherein the second data type is different than the first data type;

for each of the first and second fields, storing corresponding data type definition in a definitional data structure; and

when records having data values in the first and second fields are created for the first and second tenants, respectively, storing the data values of first and second fields to a single custom data column in the multi-tenant data structure, wherein the single custom data column includes data values having different data types for different tenants as defined by the definitional data structure.

2. The method of claim **1**, further comprising:

determining a location of the single custom data column in the multi-tenant data structure; and

for each of the first and second fields, storing the location in the definitional data structure.

3. The method of claim **1**, wherein the definitional data structure has an organization id column, the method further comprising:

determining a tenant id for each of the first and second tenants; and

for each of the first and second tenants, storing the respective tenant id in the organization id column of the definitional data structure.

4. The method of claim 1, further comprising:

determining at least one of the first data field or the second field has been flagged for indexing; and

storing, in the definitional data structure, an indication that the at least one of the first data field or the second field has been flagged for indexing.

5. The method of claim 1, further comprising storing an indication of the data type corresponding to each of the first and second fields in extensible markup language (XML) format.

6. The method of claim 1, wherein the data values of first and second fields are stored in the single custom data column as text in a canonical format.

7. The method of claim 1, further comprising:

defining a definitional data structure having one or more columns; and

in response to an indication from one of the first tenant and the second tenant that data in the first data field or the second data field, respectively, be unique, copying the data values stored in the single custom data column corresponding to the first data field or the second data field, respectively, to a column in the second definitional data structure.

8. A non-transitory computer-readable medium storing code for controlling a database system to store multiple fields for multiple tenants in a single multi-tenant data structure, the code comprising instructions to:

define a multi-tenant data structure having a plurality of custom data columns and at least one organization identifier (ID) column that stores a tenant ID value;

define a first data field for a first tenant, the first data field having a first data type;

define a second data field for a second tenant, the second field having a second data type, wherein the second data type is different than the first data type;

for each of the first and second fields, store corresponding data type definition in a definitional data structure; and

when records having data values in the first and second fields are created for the first and second tenants, respectively, store the data values of first and second fields to a single custom data column in the multi-tenant data structure, wherein the single custom data column includes data values having different data types for different tenants as defined by the definitional data structure.

9. The computer-readable medium of claim 8, wherein the code further comprises instructions to:

determine a location of the single custom data column in the multi-tenant data structure; and

for each of the first and second fields, store the location in the definitional data structure.

10. The computer-readable medium of claim 8, wherein the definitional data structure has an organization id column and the code further comprising instructions to:

determine a tenant id for each of the first and second tenants; and

for each of the first and second tenants, store the respective tenant id in the organization id column of the definitional data structure.

11. The computer-readable medium of claim 8, the code further comprises instructions to:

determine at least one of the first data field or the second field has been flagged for indexing; and

store, in the definitional data structure, an indication that the at least one of the first data field or the second field has been flagged for indexing.

12. The computer-readable medium of claim 8, the code further comprises instructions to store an indication of the data type corresponding to each of the first and second fields in extensible markup language (XML) format.

13. The computer-readable medium of claim 8, wherein the data values of first and second fields are stored in the single custom data column as text in a canonical format.

14. The computer-readable medium of claim 8, wherein the code further comprises instructions to:

define a second definitional data structure having one or more columns; and

in response to an indication from one of the first tenant and the second tenant that data in the first data field or the second data field, respectively, be unique, copy the data values stored in the single custom data column corresponding to the first data field or the second data field, respectively, to a column in the second definitional data structure.

15. A multi-tenant database system, comprising:

a database for storing multi-tenant data objects; and

a database management process configured to:

define a multi-tenant data structure having a plurality of custom data columns and at least one organization identifier (ID) column that stores a tenant ID value;

define a first data field for a first tenant, the first data field having a first data type;

define a second data field for a second tenant, the second field having a second data type, wherein the second data type is different than the first data type;

for each of the first and second fields, store corresponding data type definition in a definitional data structure; and

when records having data values in the first and second fields are created for the first and second tenants, respectively, storing the data values of first and second fields to a single custom data column in the multi-tenant data structure, wherein the single custom data column includes data values having different data types for different tenants as defined by the definitional data structure.

16. The multi-tenant database system of claim 15, wherein the database management process is further configured to:

determine a location of the single data column in the multi-tenant data structure; and

for each of the first and second fields, store the location in the definitional data structure.

17. The multi-tenant database system of claim 15, wherein the definitional data structure has an organization id column and the database management process is further configured to:

determine a tenant id for each of the first and second tenants; and

for each of the first and second tenants, store the respective tenant id in the organization id column of the definitional data structure.

18. The multi-tenant database system of claim 15, wherein the database management process is further configured to:

determine at least one of the first data field or the second field has been flagged for indexing; and

store, in the definitional data structure, an indication that the at least one of the first data field or the second field has been flagged for indexing.

19. The multi-tenant database system of claim 15, wherein the database management process is further configured to store an indication of the data type corresponding to each of the first and second fields in extensible markup language (XML) format.

20. The multi-tenant database system of claim **15**, wherein the data values of first and second fields are stored in the single custom data column as text in a canonical format.

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